9

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

HANSON RESERVOIR DAM
WHITE SULPHUR SPRINGS, MONTANA
MEAGHER COUNTY
MT 3207

prepared for

HONORABLE TED SCHWINDEN
GOVERNOR, STATE OF MONTANA

ELMER HANSON
(OWNER-OPERATOR)

prepared by

HKM ASSOCIATES
BILLINGS, MONTANA

MARCH 1981

SEATTLE DISTRICT
UNITED STATES ARMY CORPS OF ENGINEERS

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

EXECUTIVE SUMMARY

Personnel of HKM Associates, under a contract with the Montana Department of Natural Resources and Conservation (DNRC), and with representation from the DNRC, inspected Hanson Reservoir Dam on June 25, 1980. The inspection and evaluation were performed under the authority of Public Law 92-367. Hanson Reservoir is located on Woods Gulch Creek, approximately 6 miles west of White Sulphur Springs, Meagher County, Montana. The dam was built in 1932 by the father to the present owner/operator, Elmer Hanson.

FINDINGS AND EVALUATION

Hanson Reservoir stores runoff from a drainage basin of 29 square miles. There are several small stockwater ponds scattered throughout the Woods Gulch Creek drainage basin. Additionally, there is one other relatively major storage project in the Hanson Reservoir watershed, and that is Jackson Lake Dam (storage to first overtopping elevation of 490 acre-feet (AF)). Jackson Lake is located approximately 4 miles upstream of Hanson Reservoir on North Fork Woods Gulch Creek, and has a contributory watershed of 5.9 square miles.

Hanson Reservoir is primarily a single-purpose storage project in support of irrigation practices downstream. Incidental benefits related to the storage project are floodwater detention and sediment accumulation. Storage capacity to the spillway crest is estimated to be 84 AF. Total estimated storage capacity to the first overtopping dam crest elevation is 240 AF. The dam has a hydraulic height of 13 feet. On the basis of criteria in the U.S. Army Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is small in size. There is a sufficient number of inhabitable structures in the downstream flood plain that a dam failure could endanger many lives. In addition, there is a county road, a few private roads, a few private utilities, and farmland that would be affected in the event of a dam breach. The downstream hazard potential is therefore high (Category 1). However, no dam breach analysis or routing of a dam breach flood was made for the downstream area. The conclusions on probable damage are based on a brief field inspection and engineering judgment.

The guidelines recommend that the discharge and/or storage capacity of a small-size, high downstream hazard potential dam be capable of safely handling a flood of one-half Probable Maximum Flood (PMF) to a full PMF. Because of the assessed downstream risk potential (at least 3 inhabitable structures and appreciable economic loss), it is recommended the project safely handle one-half the PMF. The PMF is the flood expected from the most

severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Assuming that Jackson Lake has no effect in reducing peak and volume amounts because of its small size, the estimated PMF for Hanson Reservoir has a peak discharge of 64,100 cubic feet per second (cfs) and a total 72-hour volume of 15,400 AF.

For the flood routing, the initial reservoir pool was assumed to be at the spillway crest elevation (4922 feet, see note on page ix), and the outlet was assumed closed. Routing of the estimated PMF for Hanson Reservoir showed that the project has the capacity of controlling a flood having hydrograph ordinates approximately equal to 5 percent of the PMF hydrograph ordinates. However, because of the unstable earthen banks of the spillway, it is possible that an earthen slide could occur and cause an obstruction in the spillway channel. A detailed analysis was not performed to assess hypothetical slide events because of the informational base available and the scope of a Phase I investigation. At this level of study, it is sufficient to say that the potential exists for the spillway capacity to be reduced due to one or more earth slides.

The total outlet works facility was not capable of being field-evaluated due to the pool level at the time of survey and the fact that the conduit is too small (18 inches in diameter) to allow inspection with available equipment. The section of corrugated steel pipe which is exposed at the outlet end is severely corroded, and severe erosion of the embankment toe is taking place at the outlet.

Several seepage areas were identified during the field investigation. Free water was observed throughout the valley floor below the embankment. Field observations indicate that the seepage gradient through the embankment is nearly horizontal. Specific details relative to the phreatic surface through the embankment are unknown due to a limited informational base and the fact that field measurements could not be made.

The results of the surficial examination of Hanson Reservoir Dam generally indicate that the embankment is in poor condition. Evidence of instability was observed in the following areas: along the upstream face of the dam and along the crest where wave action has eroded the embankment face to the extent that the effective crest width has been reduced to 5 feet; on the downstream face of the embankment where slope movements were identified (Exhibit C1 of Appendix C); and at the outlet where the embankment toe has been severely eroded. The slope movements on the downstream face are characterized by surface irregularities, erosion, and a change in slope. These movements

are not considered to be active, however, their importance is related to the fact that the constructed slope appears too steep for the material and its seepage and foundation condition.

A comparison of report findings with inspection guidelines shows Hanson Reservoir has insufficient storage and/or discharge capacity to safely handle the recommended spillway design flood (SDF), which is one-half PMF. The spillway does not conform to the guidelines as it is seriously inadequate and structurally unstable. The dam embankment has major deficiencies and the corrosion existing in the corrugated steel pipe presents a very serious safety concern. For the above reasons, Hanson Reservoir Dam is considered unsafe-nonemergency until deficiencies are corrected.

RECOMMENDATIONS

Immediately develop, implement, and test a downstream warning plan, and implement a more active maintenance plan. Consider Jackson Lake in the Hanson Reservoir warning plan. Special immediate attention and rehabilitation efforts must be directed to the outlet works conduit because of its questionable condition, and to the dam embankment because of its outward signs of instability. It is recommended that the reservoir be lowered immediately to inspect the entire outlet works facility. Observe caution when using the outlet works, whether it be during normal operation, during passage of flood flows, or during lowering of the pool, so as not to accelerate the deteriorating condition of the conduit. It is recommended that lowering of the pool be performed under the direction of a qualified engineer. Appropriate repairs to the outlet works need to be accomplished prior to raising the pool. Recommended repairs on the embankment include: the reconstruction of the upstream face and dam crest; placement of rock riprap material on the upstream face; regrading the downstream face to improve slope stability, and followed immediately with revegetation; and the repair of the eroded area at the downstream toe where the outlet works exits. The entire outlet area requires reshaping and the placement of rock riprap. The spillway channel banks require reshaping to provide a stable condition.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity. Conduct and place on file stability and seepage analyses of the dam embankment. Modify the project as studies indicate.

Conduct periodic inspections of the project at 5-year intervals by engineers experienced in dam design and construction. Develop

and implement a periodic maintenance plan for the dam and appurtenant structures.

Prior to performing engineering studies and remedial construction, coordinate the work with the Montana DNRC, Dam Safety Section, to insure compliance with all pertinent laws and regulations.

Mike Keene

Michael D. Keene
Professional Engineer

MONTANA
MICHAEL D.
KEENE
4197 E
REGISTERED
PROFESSIONAL ENGINEER

PERTINENT DATA SUMMARY

1. General

Federal ID Number	MT 3207
Owner and Operator	Elmer Hanson
Purpose	Irrigation
Location	Section 13, T9N, R5E, and Section 18, T9N, R6E, MPM; 6 miles west of White Sulphur Springs, Montana
County, State	Meagher County, Montana
Watershed	Woods Gulch Creek
Hazard Potential	Category 1 (High)
Size Classification	Small

2. Reservoir

Surface Area at Spillway Crest Elevation 4922 feet (see note page ix)	28 acres
Estimated Storage to Spillway Crest Elevation 4922 feet	84 acre-feet
Estimated Storage to First Overtopping Dam Crest Elevation 4925.7 feet	240 acre-feet
Total Drainage Area	29 square miles
Reservoir Water Surface Elevation on the Day of the Inspection	4922 feet

3. Spillway

Crest Elevation	4922 feet
Control Elevation	4920.5 feet

PERTINENT DATA SUMMARY
(Continued)

Type	Uncontrolled earth and rock spillway
Control Section Width	20 feet
Spillway Capacity To First Overtopping Dam Crest Elevation	470 cubic feet per second

4. <u>Outlet Works</u>

Gate	Slidegate valve
Control	Manual operator
Conduit	Approximately 90 feet of 18-inch diameter corrugated steel pipe
Capacity	
To Spillway Crest Elevation	14 cubic feet per second
To First Overtopping Dam Crest Elevation	17 cubic feet per second

5. <u>Dam</u>

Type	Earth fill
Structural Height	13 feet (estimated)
Hydraulic Height	13 feet
Design Crest Control Elevation	Unknown
Existing First Overtopping Dam Crest Elevation	4925.7 feet
Total Crest Length	477 feet
Design Crest Width	Unknown
Existing Crest Width	Variable 5-16 feet

PERTINENT DATA SUMMARY
(Continued)

Upstream Slope (above normal water surface)	1V on 1.3H
Downstream Slope	1V on 1.6 H to 1V on 2.2H

Note: The normal water surface (NWS) is assumed to be at elevation 4922 feet NGVD based on the water surface shown on the Hanson Reservoir Quadrangle Map, 1971. Elevations will not be shown as "NGVD" since it is not known if the water surface shown on the map is exactly the NWS.

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority

This report summarizes the Phase I inspection and evaluation of Hanson Reservoir Dam. The project is owned and operated by Elmer Hanson.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive concensus of the engineering community.

Where necessary, the guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam

(2) based upon an evaluation of the available data and a visual inspection

(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted

(4) not intended to include extensive explorations, analysis or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective action.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana, Department of Natural Resources and Conservation. The owner is urged to contact the Montana DNRC prior to taking any action on report recommendations. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act, shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

The investigation process allows for report review by the Montana DNRC and the owner. Review comments are considered before final publication of the Phase I Inspection Report. Their written comments are enclosed in Appendix E.

1.1.2 Purpose and Inspection

The findings and recommendations in this report were based on visual inspection of the project, minimal field survey measurements, and review of available design and operation data. The purpose of the inspection is to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

The visual inspection of Hanson Reservoir Dam was made on June 25, 1980. HKM Associates personnel who attended the field inspection and contributed to this report were:

Dan Dyer, Geotechnical Engineer
Gary Elwell, Hydraulics/Hydrology
Mike Keene, Hydraulics/Hydrology, Team Leader

Other HKM personnel contributing to the report but not attending the field inspection were:

Dale R. Cunnington, Structural Engineer
William Hansen, Hydraulics/Hydrology
Dan Nebel, Geology

Other personnel present during the June 25, 1980 inspection included:

Glen McDonald, Supervisor, Montana DNRC, Dam Safety Section
Larry Tegg, Dam Safety Engineer, Montana DNRC, Dam Safety Section

1.2 DESCRIPTION

1.2.1 General

Hanson Reservoir Dam is an earth fill dam located in the SW 1/4 of Section 18, T9N, R6E and the SE 1/4 of Section 13, T9N, R5E, M.P.M., Meagher County, Montana (Appendix A and Ref. 2, 3). The dam is owned and operated by Elmer Hanson.

The dam and reservoir form an irrigation storage facility within the Missouri River Basin by containing the water of Woods Gulch Creek and tributaries. Outlet releases are returned directly to Woods Gulch Creek. Woods Gulch Creek travels approximately 0.9 mile before reaching a county road embankment, and then another 0.5 mile before joining the Smith River (Appendix A and Ref. 2). The nearest downstream community is Fort Logan, Montana, which is located on the west bank of the Smith River approximately 12 miles northwest of the dam. In terms of a stream channel distance, Fort Logan is located 15 miles downstream of the dam. There are several homes located in the downstream flood plain of Woods Gulch Creek and the Smith River.

Hanson Reservoir Dam has a hydraulic height of 13 feet and impounds approximately 240 AF at the first overtopping dam crest elevation (elevation 4925.7 feet, see note page ix). Based on a visual reconnaissance and engineering judgment, at least three residences, as well as county and private roads, private utilities, and agricultural land would be affected by a sudden breach of the dam. It is assumed the county road embankment will breach in the event of a Hanson Reservoir Dam breach. On the basis of this information and in accordance with the Recommended Guidelines (Ref. 1), the project is classified small in size and the downstream hazard potential is high (Category 1).

Hanson Reservoir Dam was constructed to provide storage and regulation in support of irrigation practices. Incidental benefits are provided for floodwater detention and sediment accumulation. Storage to the normal pool level, or the spillway crest (elevation 4922.0 feet) is estimated to be 84 AF (Ref. 2 and Exhibit D1). An additional 156 AF are available for flood surcharge storage between the spillway crest and the first overtopping dam crest elevation.

Hanson Reservoir Dam has a total upstream contributory drainage area of 29 square miles. Several water storage facilities exist in the drainage basin. The largest of these facilities is Jackson Lake having a storage capacity of approximately 370 AF. For routing purposes, it is assumed that none of these facilities will provide detention storage in the case of a large flood event. The Hanson Reservoir watershed is characterized by foothill, prairie, and flat plain drainages. Elevations in the basin range from 7981 feet NGVD to about 4922 feet NGVD at the reservoir (Ref. 3). The reservoir is located in open, generally flat terrain (Photo 1 of Appendix B).

1.2.2 Regional Geology

Hanson Reservoir Dam is situated on the west edge of the Smith River valley, a structurally complex region between the Big Belt uplift to the west, the Little Belt uplift to the east and the Castle Mountain dome to the south and east. The topography of the immediate area is composed of low, subdued shale hills. The strata shows a uniform east-southeast dip of about 30 degrees with the Deep River-Fort Logan Formations (Tertiary) forming the surface of the area. Faulting is extensive in the area with major thrust faults extending the length of the Smith River valley east of White Sulphur Springs and numerous normal and reverse faults bordering the Big Belt uplift immediately west of the dam site. There is, however, no evidence of recent fault movement activity (Ref. 4).

1.2.3 Seismicity

Hanson Reservoir Dam is in a moderately active to active seismic zone with the majority of the region's seismic events occurring in the southwestern Montana-Yellowstone Park area. Since 1925, Montana has experienced five shocks that reached intensity VII or greater (Modified Mercalli Scale).

The closest epicenter of an intensity VIII or greater shock occurred in the Helena, Montana area which is approximately 45 miles west of the damsite. Numerous other shocks of intensity IV or greater have been reported within a 100-mile radius of the

site (as of January 1974). The site is located in zone 3 of the Seismic Zone Map of Contiguous States, and it can be assumed that a major earthquake may occur within the life of the structure (Ref. 1, 5). Although the Zone Map is based on a known distribution of damaging earthquakes, it does not necessarily reflect accurate or adequate seismic design parameters for this site.

1.2.4 Site Geology

No drill hole or site reconnaissance data for the dam is available. This section of the report is developed from regional geologic information and personal knowledge of the area.

The reservoir basin is composed of sandy and silty shale and shaly sandstone of Tertiary age. The alternating shale and sandstone bedding is fairly uniform in thickness averaging three to four inches. The valley section consists of thin alluvial deposits of sand, gravel, clay, and weathered shale. Based on field investigation it appears sediment should not be a problem.

The outlet works and stilling basin are located on alluvium which has not been protected by angular riprap. During the field inspection it was noted that slumping and erosion is occurring in the outlet works area.

1.2.5 Design and Construction History

Hanson Reservoir was built in 1932 by the father of the current owner/operator, Elmer Hanson. Evidently, no special design team or contractors were employed on the project. Water is stored and released for downstream irrigation purposes.

Few improvements or repairs have been made to Hanson Reservoir since 1932. It is reported that a couple small storage ponds washed out in 1943 or 1944, which in turn caused a small washout at Hanson Reservoir. Specifics of the Hanson Reservoir washout are unknown. About 15 years ago, a new pipe section for the outlet works was installed on the upstream end due to ice damage. The new section was of a lighter metal gauge than the original pipe. Work was performed during the spring of 1980 on the existing outlet works gate frame and gate stem. Additional work was completed during November 1980 (see Appendix E - Correspondence.

There are no design calculations, drawings, quality control testing results, inspection results, or dam and reservoir statistics available for review.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for Hanson Reservoir Dam is located on the left (west) side. The spillway is composed of earthen banks and a bedrock channel bottom. The cross-section and bed material are both irregular in shape and size (Photo 2 of Appendix B). The inlet channel is approximately 30 feet in length and varies from an effective width of 50 to 75 feet at the crest to 40 to 45 feet effective width 30 feet downstream (Exhibits C1 and C3 of Appendix C). At a point 75 to 100 feet downstream from the spillway crest the base width is 18 feet. The left bank at this point is nearly vertical with a bank height of 18 inches. The right bank is 4 feet high with a flatter slope of 1V on 3H to 1V on 4H. The spillway channel has a mild positive slope from the spillway crest to a major drop in the spillway channel located approximately 180 feet downstream of the crest. The vertical drop is 8 to 10 feet at its deepest point, which is to the bottom of a scour hole. The channel width in this area is 15 to 20 feet with vertical sidewalls. The left bank consists of a 5-foot layer of sand and clay material overlying rock. The right bank is composed entirely of rock. A bend of approximately 70 degrees occurs 50 to 60 feet downstream of the vertical drop. Downstream of the bend, the channel maintains a very irregular shape (Photo 3 of Appendix B). The right channel bank becomes vertical and is 7 to 8 feet high. The left bank varies in slope from 1 vertical (V) on 3 horizontal (H) to vertical. The channel in this area obtains a maximum width of 30 feet, but is generally less than 15 feet wide. The spillway channel returns to Woods Gulch Creek 250 to 300 feet downstream of the dam. At this point the spillway channel is approximately perpendicular to Woods Gulch Creek. A small stilling pool is located in the spillway channel immediately upstream of the confluence with Woods Gulch Creek, but is not well defined at this time. No riprap is evident in the stilling area. The return area is extremely flat and open, and the entire valley could carry flood flows. It appears spillway flows and energy dissipation have not been a problem in the past. However, because of the unstable earthen banks of the spillway, it is possible that an earthen slide could occur and cause an obstruction in the spillway channel. A detailed analysis was not performed to assess hypothetical slide events because of the informational base available and the scope of a Phase I investigation. At this level of study, it is sufficient to say that the potential exists for the spillway capacity to be reduced due to one or more earth slides.

Spillway rating information was not available. Therefore, new hydraulic rating information was developed using the computer program HEC-2 (Ref. 14). It is assumed that the control section is at the vertical drop and that the bed slope is sufficiently steep downstream to prevent backwater effects. Spillway capacity to the first overtopping dam crest elevation (4925.7 feet, see note page ix) is 470 cfs.

2.1.2 Outlet Works

The outlet works for Hanson Reservoir Dam is located about 250 feet from the right abutment contact and aligned approximately perpendicular to the dam crest (See Exhibit C1). Limited information is available about the outlet works. From the field investigation it was determined that the outlet is constructed of 18-inch corrugated steel pipe (CSP) and is controlled by a slidegate valve on the upstream face of the dam. The owner indicated a section of outlet pipe had come off the downstream end and an additional section of pipe had been added to the upstream end because of ice damage.

The outlet works is in extremely poor condition. The CSP is severely corroded from the flowline up to about 75 percent of the conduit height (Photo 4 of Appendix B). The embankment is vertical at the outlet, with the top of the pipe 4 feet below the top of the vertical section of the embankment. Severe erosion is occurring below and on both sides of the outlet conduit. Scouring extends approximately 5 feet back into the earth embankment, and extends about 2 to 3 feet on either side of the conduit (Photos 4 and 5 of Appendix B). There is a horseshoe shaped scour hole 3 to 4 feet deep and 3 to 4 feet downstream of the pipe outlet. The appex of the horseshoe is approximately 30 feet from the pipe outlet. The scour hole presently acts as a plunge pool and provides energy dissipation for outlet works flow. Downstream of the plunge pool, the return channel assumes a section 8 to 9 feet wide and generally parabolic in shape with a flow depth of 12 to 24 inches. The channel banks and horizontal alignment are irregular. The overbank areas are relatively flat and covered with a dense mixture of grasses.

The interior of the pipe could not be inspected due to its small size and the pipe inlet could not be inspected due to the pool level at the time of the investigation. The wheel on the operating gate stem has been removed and there is a bend in the stem at the very top (Photo 6 of Appendix B). Without the owner and proper equipment it was not possible to operate the gate. The owner indicates the gate was in a slightly open position and had been fully closed last fall. By visual inspection, it appeared that the stem was in the fully closed position, although

the pipe was flowing approximately half full at the outlet. There was very little tailwater influence at this discharge. The invert of the outlet pipe on the downstream side of the dam was found by field survey to be 4913 feet, which is about 13 feet below the dam crest.

Outlet works rating information was not available. New hydraulic rating information was calculated using the energy equation assuming the gate is in the fully open position, full conduit flow exists throughout the entire length and that a representative value for Mannings "n" is 0.025. Outlet works capacity to the spillway crest elevation (4922 feet, see note page ix) and the first overtopping dam crest elevation (4925.7 feet) is 14 cfs and 17 cfs, respectively. Due to the extremely poor condition of the outlet works, specifically corrosion of the pipe and erosion around the outlet, the outlet works capability is severely limited.

2.1.3 Freeboard

The guidelines' (Ref. 1) recommended spillway design flood for a small, high hazard dam falls in a range of 0.5 PMF to PMF. Based on the downstream hazard, we recommend a spillway design flood of 0.5 PMF. Flood routing (Section 2.2.3) indicates the dam overtops during the 0.5 PMF event, and therefore, no freeboard exists for such conditions. The vertical distance from the spillway crest (elevation 4922 feet, see note page ix) to the first overtopping dam crest elevation (4925.7 feet) is 3.7 feet. The owner indicates that a probable historic highwater level for Hanson Reservoir, as a result of natural flooding, occurred about 3 years ago in the spring (exact date and elevation unknown). Higher pool levels for a short period of time were experienced in 1943 or 1944 following washouts of two small upstream storage ponds. The vertical distance between the reservoir pool and the first overtopping at the time of the June 1980 field inspection was 3.7 feet.

Hanson Reservoir is basically oriented in a north-south direction, with the dam on the north side. The prevailing wind for this region is generally identified as being westerly (Ref. 6, 7). The reservoir location and orientation can be observed in Appendix A. The effective fetch length for this orientation is calculated to be 0.5 mile. Hence, a minimum freeboard allowance should be about 3 feet (Ref. 8). Although the dam will overtop during the spillway design flood and lesser floods, the vertical distance between normal pool level and the first overtopping dam crest elevation is sufficient to prevent overtopping by wind generated waves.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

The 29-square mile catchment area above Hanson Reservoir is basically rectangular in shape, with the length dimension being considerably greater than width (Appendix A). In particular, the drainage area is approximately 8.5 miles long and only 4.5 miles wide. The topography includes flat plains, rolling prairies, and foothills. The immediate vicinity of the reservoir can primarily be characterized as open and generally flat. The watershed rises from the reservoir in a southwesterly direction by gradual slopes and bench lands to the foothills of the Big Belt Mountains. Several water storage facilities exist in the Hanson Reservoir drainage basin, the largest of these being Jackson Lake.

Soils in the lower portion of the drainage area are generally loams with mountain grassed and forested soils in the upper elevations (Ref. 9). Numerous springs are evident in the basin.

The regional climate is classified as distinctly continental, and characterized by abundant sunshine, low relative humidity, moderate rainfall, and wide daily and seasonal variations in temperature. However, the regional climate does not have the extreme variable pattern common to the more mountainous western sections in Montana. In general, the valleys are relatively dry during the colder months and wet during the late spring and early summer. The wettest part of the year in the mountains is generally from midwinter to early spring. It is not uncommon for the region to experience winter warming spells with associated thawing temperatures. Precipitation in the Hanson Reservoir vicinity ranges from about 17.5 inches at White Sulphur Springs (6 miles east of the dam) to amounts in excess of 30 inches in the foothills of the Big Belt Mountains. The average annual temperature at White Sulphur Springs is approximately 41 degrees Fahrenheit. Winters are typically cold, with January being the coldest month. The monthly average temperature for January at White Sulphur Springs is about 20 degrees Fahrenheit. During the summer, July is typically the warmest month with an average temperature of about 64 degrees Fahrenheit (Ref. 6, 7). It is assumed that saturated, not frozen, ground conditions would be present during a typical June rainfall flood event.

No streamflow measurements on Woods Gulch Creek or pool level records on Hanson Reservoir are available.

2.2.2 Estimated Probable Maximum Flood (PMF)

The probable maximum precipitation (PMP) and the estimated probable maximum flood (PMF) were developed for the Hanson

Reservoir drainage basin. The ratio of the reservoir area to the non-reservoir area is less than 1 percent; therefore, the two areas were not separated for the purpose of this analysis.

The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the study region.

Hanson Reservoir is located west of the 105th meridian and east of the continental divide, hence PMP values were calculated using procedures associated with the National Weather Service Interim Method (Ref. 10). The Interim Method provides PMP values for durations of 6 to 72 hours, with PMP values for 1 to 5 hours obtained by multiplying the 6-hour PMP value by percentages supplied by the Corps of Engineers, Seattle District. The PMP 6-hour, 12-hour, 24-hour, 48-hour, and 72-hour values were 9.2 inches, 11.1 inches, 13.5 inches, 15.7 inches and 17.0 inches, respectively. The 6-hour PMP value of 9.2 inches was multiplied by 67 percent, 78 percent, 85 percent, 91 percent, and 95 percent to obtain PMP values of 6.2 inches, 7.2 inches, 7.8 inches, 8.4 inches and 8.7 inches for durations of 1-hour, 2-hours, 3-hours, 4-hours, and 5-hours, respectively.

The 6-hour increments for the total 72-hour storm were arranged in a critical distribution using criteria presented in the National Weather Service Hydrometeorological Report No. 43 (Ref. 11). In particular, the 6-hour rainfall increments were arranged according to pattern "e". Further subdivision of the calculated rainfall increments was required to provide compatibility with the duration of the unit hydrograph. A 15-minute unit hydrograph was chosen for Hanson Reservoir using criteria presented in the SCS Hydrology Handbook (Ref. 12). The unit hydrograph was developed for the Hanson Reservoir basin using the U.S. Army Corps of Engineers' computer program HEC-1 and the SCS method (Ref. 12, 13). The PMP storm was plotted in the form of a depth-duration curve for convenience in selecting incremental rainfall values. The peak 15-minute PMP values, within the time base of the unit hydrograph, were ordered according to the reverse pattern of the unit hydrograph ordinates.

Rainfall losses were assumed equal to the minimum soil retention rate of 0.15 inches/hour for type B soils (Ref. 12) due to an assumed saturated ground condition.

The runoff condition, or PMF, resulting from a PMP storm was estimated using the PMP values and the unit hydrograph approach. The resultant PMF has a peak flow of 64,100 cfs and a 72-hour volume of 15,400 AF.

2.2.3 Flood Routing

The PMF resulting from the PMP rainfall/runoff event was routed through Hanson Reservoir using the computer program HEC-1 (Ref. 13). Runoff from an antecedent storm was not specifically considered; however, it appears reasonable to assume the initial reservoir level prior to routing the PMF is at the spillway crest (elevation 4922.0 feet, see note page ix). The support rationale for this assumption is that Hanson Reservoir is not capable of totally absorbing rather severe flood events due to its small size. In addition, a rapid pool drawdown by operating the outlet works at or near full capacity is not recommended due to the extremely poor condition of the outlet pipe and the likely severe erosion near the pipe outlet.

Reservoir area-capacity-elevation data was not available. New data estimated from a U.S.G.S. quadrangle map (Ref. 2) is provided in Exhibit D1 of Appendix D. Discharge rating data is shown in Exhibits D2 and D3 of Appendix D. Flow through the outlet works was not included in the flood routing due to the extremely poor condition of the outlet works.

For the purposes of flood routing and according to inspection criteria, the dam crest elevation is the minimum elevation to which the reservoir must rise before overtopping the dam. This criteria assumes overtopping and failure of embankment-type dams to be coincidental. Based upon the embankment profile survey dated June 25, 1980 (Exhibit C2 of Appendix C), the existing low-point dam crest elevation is 4925.7 feet.

Flood routing showed that the dam would first overtop during the PMF when approximately 4 percent of the total PMF volume enters the reservoir. Routings were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 5 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

2.3 GEOTECHNICAL EVALUATION

The geotechnical evaluation of Hanson Reservoir Dam included a field investigation and a search and review of project design data. The field inspection consisted of photo documentation, a dam crest profile survey, slope stability observations of the dam embankment, seepage observations, and measurements of the slope angles. Inspection photos are included in Appendix B. Field sketches of the project are included in Exhibit C1 and C3 of Appendix C, and the crest profile survey is shown in Exhibit C2. Results of the slope angle measurements are provided in Exhibit C1.

2.3.1 Dam Embankment

Hanson Reservoir Dam is an earth fill structure which was completed in 1932. The dam has an estimated hydraulic and structural height, based on the field profile survey, of 13 feet and a total crest length of 477 feet. Construction drawings and specifications of the facility are not available. Approximate drawings of the reservoir plan view and the embankment cross-section were prepared in the field and are presented in Exhibit C1 of Appendix C. Crest width, length and slope angle field measurements were used to describe the embankment configuration.

The crest width varies from 5 to 16 feet (Photo 7 of Appendix B). The variable width is a result of wave-type erosion on the upstream face. This erosion will be further described in a following section. Small erosion gullies have developed on the upstream face at both abutment contacts due to localized runoff.

The downstream face has a varying slope of from 1V on 1.6H near the crest and at the maximum section to 1V on 2.2H. Slope angles measured in the field are shown in Exhibit C1 of Appendix C. The upstream slope has been oversteepened by wave action above the normal water surface to a slope of about 1V on 1.3H, which flattens below the water surface. Wave action has created a small sloping berm near the normal water elevation. The slope below the water surface is unknown. Debris is not a problem on the upstream slope. The downstream slope has a moderate to light cover of natural grasses and weeds and has some damage due to cattle and burrowing animals (Photo 8 of Appendix B).

The embankment cross-section materials are unknown except for those exposed. There are a few scattered cobbles on the upstream face but, in general, there is no riprap protection. The soils exposed on the crest are weathered shales and argillites with an estimated average grain size of 1/4 to 1/2 inch and with few fines. At the outlet where the embankment materials are exposed to a horizontal depth of 5 feet into the toe, the material is a sandy clay with low cohesion and plasticity, and high erodibility. It is not known if there is an impermeable zone in the embankment or a cutoff trench under it.

2.3.2 Foundation Conditions and Seepage Control

Neither soil boring or test pit logs were available for review. It is doubtful that any foundation investigation was performed prior to construction.

Based on field observation of the surface material and the topography, it appears that the main section of the embankment may be founded on thin alluvial deposits of sand, gravel, clay, and weathered shale. Bedrock is fractured shale, mudstone, and argillites. This material is relatively permeable along the bedding planes which would indicate possible seepage through the foundation materials.

In summary the foundation appears stable but the actual material types, strengths, and thicknesses are unknown.

Settlement

An embankment profile was surveyed on June 25, 1980 (Exhibit C2 of Appendix C). The survey shows that the differential elevation along the crest is very small (about 0.5 feet). The dam was either designed without camber or the camber has settled out.

A history of settlement along the dam embankment is not available. The apparent minor settlements to date have not caused significant structural damage. Because of the age of the dam (48 years), additional significant amounts of settlement are not anticipated.

Seepage

It is not known if there is a seepage control system under the embankment. Based on the presence of seepage it is assumed that either there is no control system or it is not functioning. A drain outlet was not observed.

At the time of the June 1980 field investigation, the water elevation in Hanson Reservoir was at the spillway crest (water surface elevation 4922 feet, see note on page ix). Several seepage areas were identified during this investigation. Free water was observed throughout the valley floor area downstream of the embankment and along the toe of the embankment. At the left abutment seepage was exiting at an elevation of within 2 to 3 feet of the pool elevation indicating the seepage gradient is very flat through the abutment. Saturated soils throughout the valley floor appear for 100 to 200 yards downstream from the embankment. It is not known if this water is coming from seepage under the dam or natural spring activity.

Seepage was not observed on the downstream slope. Based on the observations made in the eroded area around the outlet conduit, it appears that this portion of the embankment is saturated below an imaginary line drawn from the pool elevation on the upstream side to the downstream toe, however, the actual location of the phreatic surface is unknown.

2.3.3 Stability

The slope angles measured during the field investigation are shown in Exhibit C1 of Appendix C. These angles were measured with an Abney level and should be considered approximate.

Outward signs of instability are evident from visual inspection of the embankment structure. Items of particular concern are listed below.

1. Wave action has eroded the upstream face of the embankment thereby reducing the effective crest width to 5 feet (Photo 9 of Appendix B).

2. The embankment has been severely eroded around the outlet conduit. The eroded area has a vertical bank height of about 4 feet (Photo 5 of Appendix B). The embankment is saturated in this area. The downstream face at this area is unstable.

3. Slope movements were identified on the downstream face of the embankment by surface irregularities, erosion and a lack of vegetation, and a change in slope. These movements appear to be primarily surface material, however, the depth of the movements is unknown. The movements are located in the foreground of Photo 9 of Appendix B and as represented in Exhibit C1. At the time of this investigation, seepage was not exiting on the slope and the slope movement was not active. Past slope movements suggest, however, that the downstream slope is too steep for the material and its seepage and foundation condition.

There is no embankment design information available. It is assumed that soil strength tests were not performed and slope stability calculations were not made as there are none available. The embankment does not contain piezometers and the actual hydrostatic conditions are unknown.

The soils overlying the bedrock along the spillway channel banks, downstream of the vertical drop, have been oversteepened. This material is unstable and shows evidence of recent sloughing (Photo 3 of Appendix B).

The reservoir shorelines are considered to be in stable condition as no major slides or scarpments were observed. The shoreline is occasionally vertical, or near vertical, and localized sloughing

occurs due to wave action and saturated conditions (Photo 10 of Appendix B).

Due to the excessive erosion of the upstream slope, steepness and irregularities of the downstream slope, the narrow crest, and the possible high phreatic surface, the dam embankment stability does not conform to the Recommended Guidelines (Ref. 1).

2.4 PROJECT OPERATIONS AND MAINTENANCE

Hanson Reservoir is owned and operated by Elmer Hanson. The project was built to support downstream irrigation practices. There is no formal operation plan, and operation records are not kept. Storage and releases from the reservoir are generally dictated by the spring runoff and irrigation season water requirements. Occasionally pool drawdown is required to perform maintenance work.

At this particular time, gate operation for the low-level outlet is accomplished by hammering for closure and by mechanical hoist for opening. Repairs on the gate stem and frame were performed in the spring of 1980. Additional work was completed in November 1980 (see Appendix E - Correspondence). The only other maintenance required on the outlet works occurred about 15 years ago when a new pipe section was added at the upstream end. The replacement was required due to ice damage, and the repair was made by the owner. It is reported that the same type of pipe material and size was replaced, but of a lighter gauge thickness.

The spillway is an uncontrolled facility. The owner/operator indicates that the spillway flows on a regular basis during the spring and early summer period. No maintenance has been performed on the spillway since its original construction.

Embankment repair at Hanson Reservoir was required on a small washout which occurred in 1943 or 1944 as a result of small storage pond washouts upstream. Specific information concerning repairs to the dam embankment or the downstream effects of this washout is unknown. Additional work was completed in November 1980 (see Appendix E - Correspondence).

Regular, organized inspections of Hanson Reservoir have not historically been performed, and inspection records have not been kept. The project is inspected on an incidental basis, however, in that the owner/operator is commonly in the vicinity operating the control gate and/or farming the land.

There is no formal warning plan of action in the event of dam distress at Hanson Reservoir. Jackson Lake is located upstream

of this project, and it too, does not have a formal warning plan of action. Potentially impacted residences are located downstream of Hanson Reservoir. Though not part of a formal plan, potentially impacted residences would be alerted of a distress condition using radios, phone, or door-to-door contact.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in accordance with the guidelines (Ref. 1) and the contract performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification and Safety Evaluation

In accordance with the inspection guidelines (Ref. 1), Hanson Reservoir Dam is classified small in size and, based on our visual inspection and judgment, it has a high downstream hazard potential. Therefore, the guidelines' recommended spillway design flood (SDF) for this project is in a range of 50 to 100 percent of the PMF. Based on the limited number of inhabitable structures and economic loss from a dam failure, the spillway design flood was chosen to be 50 percent of the PMF. The project can handle a flood having 5 percent of the PMF hydrograph ordinates without overtopping and causing the dam to fail which, in our judgment, would seriously jeopardize life and property downstream. Based on reconnaissance level investigations, the spillway is seriously inadequate and does not conform to the guidelines (Ref. 1). The embankment deficiencies and outlet works condition pose serious structural hazards. Under inspection guideline criteria, Hanson Reservoir Dam is considered unsafe-nonemergency until the recommended actions are complete.

Jackson Lake is located about 4 miles upstream of Hanson Reservoir on North Fork Woods Gulch Creek. It is felt that a breach of Jackson Lake Dam will cause a failure of Hanson Reservoir Dam.

3.1.2 Spillway

The earth and rock spillway system was designed to accommodate a relatively small flood event compared to current standards. It is reported, however, that the spillway has performed satisfactorily in the past. The one exception would be the accommodation of the large peak, short duration flow which occurred as a result of upstream storage pond washouts in 1943 or 1944. Maximum spillway capacity, assuming the reservoir pool is at the overtopping dam crest elevation (4925.7 feet, see note page ix) is approximately 470 cfs. The floodwater storage capacity between the spillway crest (4922.0 feet) and the first overtopping dam crest elevation amounts to 156 AF. In comparison, the PMF for the 29 square-mile drainage area (including the Jackson Lake drainage area) is estimated to have a

total 72-hour runoff volume of about 15,400 AF. Hence the combination of reservoir storage and spillway discharge capability is inadequate to prevent overtopping of the dam during the recommended SDF. It appears spillway flows and energy dissipation have not been a problem in the past. However, because of the unstable, earthen banks of the spillway, it is possible that an earthen slide could occur and cause an obstruction in the spillway channel. A detailed analysis was not performed to assess hypothetical slide events because of the informational base available and the scope of a Phase I investigation. At this level of study, it is sufficient to say that the potential exists for the spillway capacity to be reduced due to one or more earth slides.

3.1.3 Outlet Works

It was not possible to inspect the intake structure and the pipe throughout its total length because of the pool level at the time of the survey and the small diameter of the pipe.

The outlet works is in extremely poor condition. The exposed section of the corrugated steel pipe is severely corroded. Severe erosion around the outlet pipe extends approximately 5 feet back into the earth embankment. There is a 3 to 4 foot deep, horseshoe shaped scour hole 3 to 4 feet downstream of the pipe outlet. Visual inspection indicated the gate stem was in approximately the closed position, yet the outlet pipe was flowing half full at the exit. The gate stem was bent which probably explains the inability to get a complete seal at the gate.

3.1.4 Dam

Outward signs of embankment instability include erosion on the upstream face due to wave action producing an effective minimum crest width of 5 feet, erosion and oversteepening of the embankment adjacent to the outlet pipe on the downstream side, and slope movement on the downstream face to the right of the outlet conduit. Seepage is evident throughout the downstream valley floor and at the toe of the embankment. The phreatic surface through the embankment is unknown but could be assumed to be a straight, imaginary line, drawn from the pool elevation on the upstream slope to the downstream toe. Small erosion gullies were evident on the upstream face at both abutment contacts.

3.1.5 Operation and Maintenance

There are no formal operation plans or maintenance programs for Hanson Reservoir. Also, there are no regular, organized

inspections of the project. Project records are generally not kept. Project operation is performed according to seasonal factors; in particular, the spring-early summer runoff is stored to the maximum extent possible, and later released to satisfy downstream irrigation requirements. The uncontrolled spillway is reported as operating most every year. Maintenance and repair have been performed on the embankment and the outlet works gate controls. Additional work was completed during November 1980 (see Appendix E - Correspondence). Hanson Reservoir is inspected only on an incidental basis by the owner/operator. There is no formal warning plan of action in the event of dam distress at Hanson Reservoir.

3.2 RECOMMENDATIONS

The investigation findings require a high priority be given to the following recommendations.

(1) Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam distress. The warning plan for Hanson Reservoir should be consolidated with any plan developed for Jackson Lake. Warn potentially impacted residents downstream of the reservoir of the poor condition of the dam.

(2) Immediately lower the reservoir and inspect the entire outlet works facility. Observe caution when using the outlet works, whether it be during normal operation, during passage of flood flows, or during lowering of the pool, so as not to accelerate the deteriorating condition of the conduit. It is recommended that lowering the pool level be performed under the direction of a qualified engineer. The inspection and required replacements/repairs need to be accomplished prior to raising the pool.

(3) Perform the following repairs on the embankment: reconstruct the upstream face and dam crest to provide a minimum crest width of 12 feet; place a weather resistent rock riprap material and bedding material, as required, on the upstream face; regrade the downstream face to provide uniform stable slopes, repair cattle damage and revegetate; repair the eroded area at the embankment toe where the outlet works exits with a rock backfill.

(4) Reshape and add rock riprap to the outlet works stilling pool.

(5) Reshape the spillway channel banks to provide a stable condition.

(6) Repair the small erosion gullies on the upstream face at both abutment contacts.

The above recommendations will not totally overcome the unsafe condition but will reduce involved risks while the following recommendations with subsequent actions are being accomplished.

(7) Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity and modify the project as studies indicate. Include upstream impoundments in these studies.

(8) Conduct and place on file stability and seepage analyses of the dam embankment. It is recommended that these analyses be performed by an experienced geotechnical engineer. Modify the dam as studies indicate to insure conformance with inspection guidelines stability criteria.

(9) Conduct periodic inspections by qualified engineers at least once every five years to determine whether there are any deficiencies in the condition of the project, to assess the adequacy and quality of maintenance, and to evaluate methods of operation. Include an inspection of the total length of the conduit through the embankment in this program.

(10) Develop and implement a periodic maintenance plan for the dam and appurtenant structures.

Prior to performing engineering studies and remedial construction, coordinate the work with the Montana DNRC, Dam Safety Section, to insure compliance with all pertinent laws and regulations.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams". Washington, D.C., Department of the Army, May 1975.

2. U.S. Geological Survey, 7-1/2 Minute Quad Map, Hanson Reservoir, Montana, 1971.

3. U.S. Geological Survey, White Sulphur Springs, Montana, AMS, Scale 1:250,000, 1958 with revision 1972.

4. Groff, S.L., Reconnaissance Groundwater and Geologic Studies of Western Meagher County, Montana, Montana Bureau of Mines and Geology, Special Publication 35, 1965.

5. Von Hake, C.A., Earthquake Information Bulletin, USGS, Vol. 10, No. 4, 1978.

6. National Oceanic and Atmospheric Administration, Climatological Data, Montana, National Climatic Center, Asheville, N.C.

7. National Oceanic and Atmospheric Administration, Climates of the States, Volume II, "Western States Including Alaska and Hawaii", Port Washington, N.Y., 1974.

8. U.S. Bureau of Reclamation, Design of Small Dams, 2nd. Edition, 1973, Revised Reprint, 1974.

9. Department of Planning and Economic Development, State of Montana, "Comprehensive Area-Wide Water and Sewer Plan, 1970, State of Montana, Meagher County", 1971.

10. National Weather Serivce, Interim All-Season Probable Maximum Precipitation Estimates, Missouri River Drainage West of the 105th Meridian, January 1, 1980.

11. National Weather Service, Hydrometeorological Report No. 43, Probable Maximum Precipitation, Northwest States, Washington, D.C., 1966.

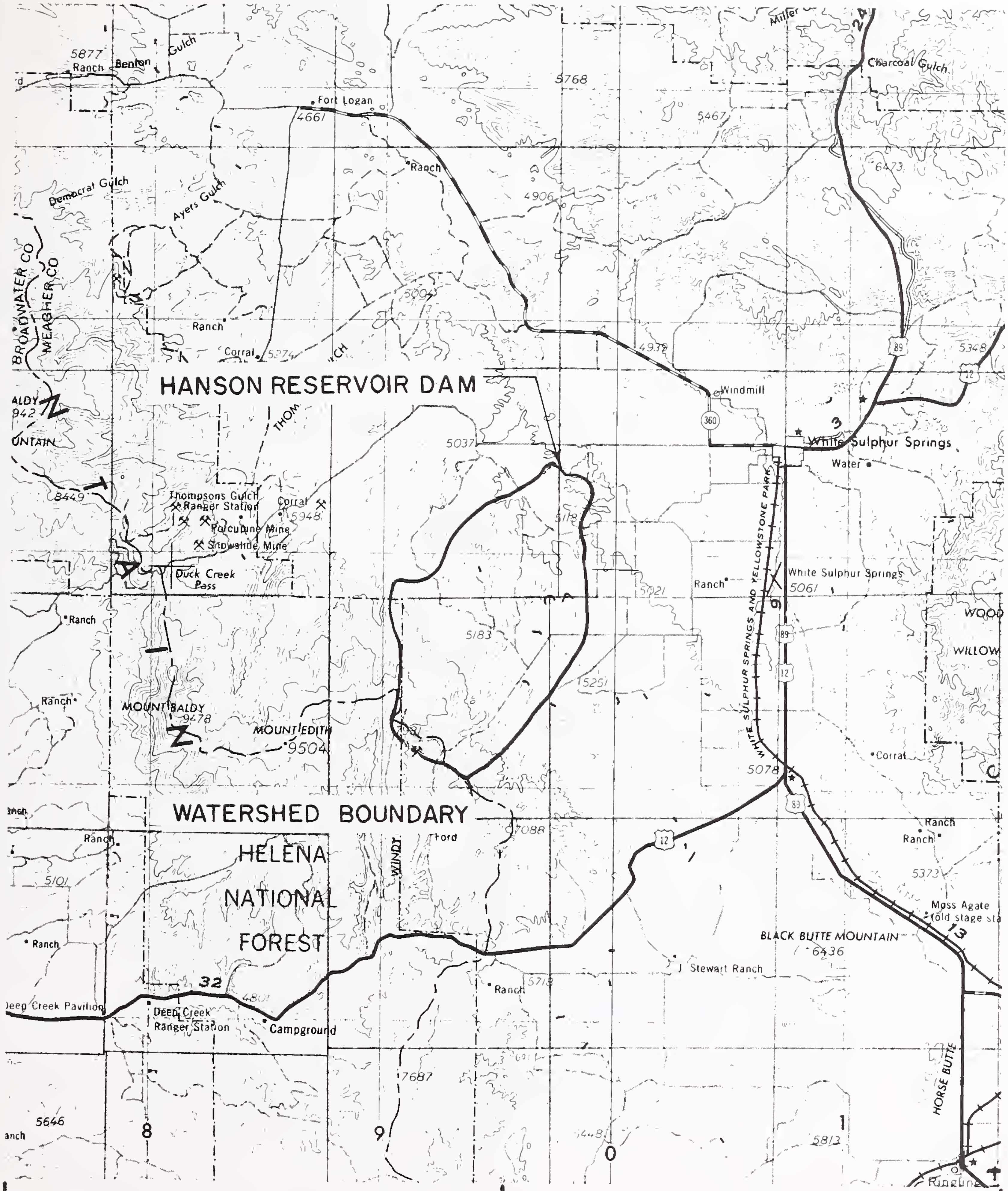
12. U.S. Soil Conservation Service, National Engineering Handbook, Section 4, "Hydrology", Washington, D.C., 1969.

13. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, September, 1978.

14. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Davis, California, October, 1973.

APPENDIX A

VICINITY & WATERSHED MAP



5 0 5 MILES

SCALE

N

SOURCE: WHITE SULPHUR SPRINGS, MONTANA AMS MAP, U.S.G.S.

APPENDIX A

VICINITY & WATERSHED MAP

HANSON RESERVOIR DAM

APPENDIX B

INSPECTION PHOTOS

Photo No. 1 - Drainage Basin.
The drainage basin rises to the foothills of the Big Belt Mountains.

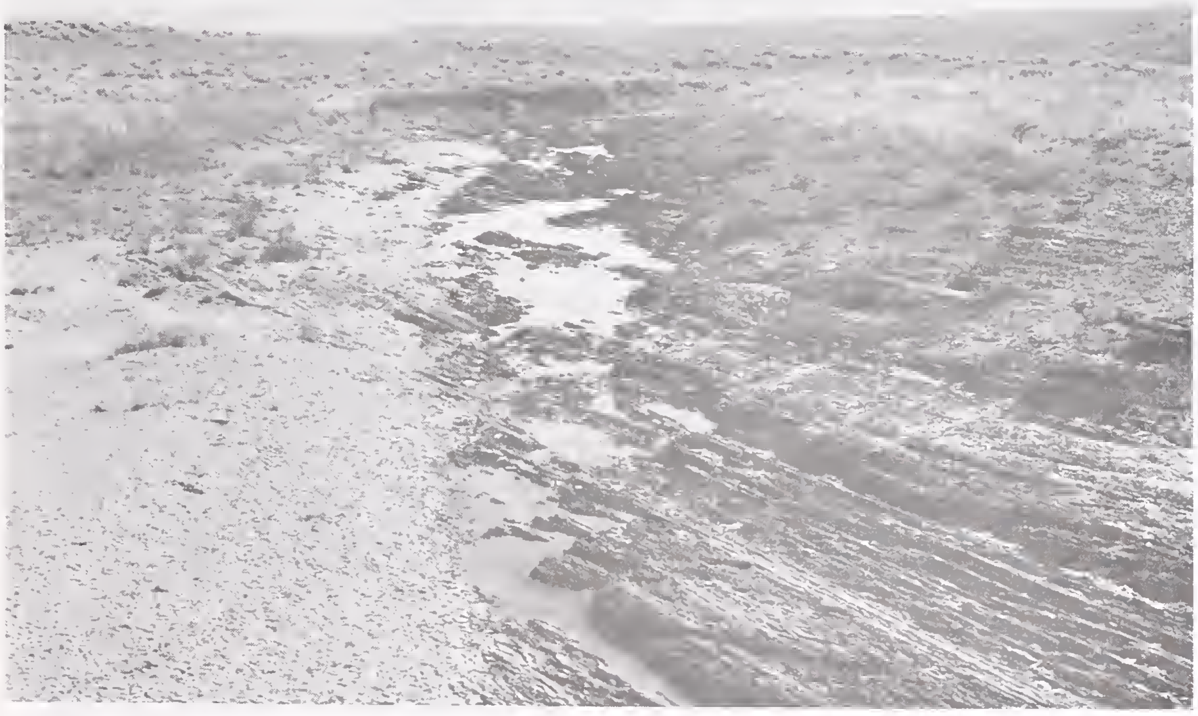


Photo No. 2 - Spillway.
The spillway transitions from a broad section at the crest (bottom of photo) to a narrow section where the channel makes a vertical drop (top of photo).

Photo No. 3 - Spillway.
Downstream of the control (vertical drop) the spillway channel banks are oversteepened and sloughing.

Photo No. 4 - Outlet Works.
The embankment on the right side of the outlet pipe is severely eroded, and the pipe is corroded and leaking water.

Photo No. 5 - Outlet Works.
Severe embankment erosion is occurring around the outlet pipe. The pipe is flowing half full with the operating gate valve stem slightly open.

Photo No. 6 - Outlet Works.
The stem on the manual gate valve operator is severely bent.

Photo No. 7 - Dam Embankment.
Shown is the dam embankment looking towards the west.

Photo No. 8 - Dam Embankment.
Rodent holes exist throughout the dam embankment.

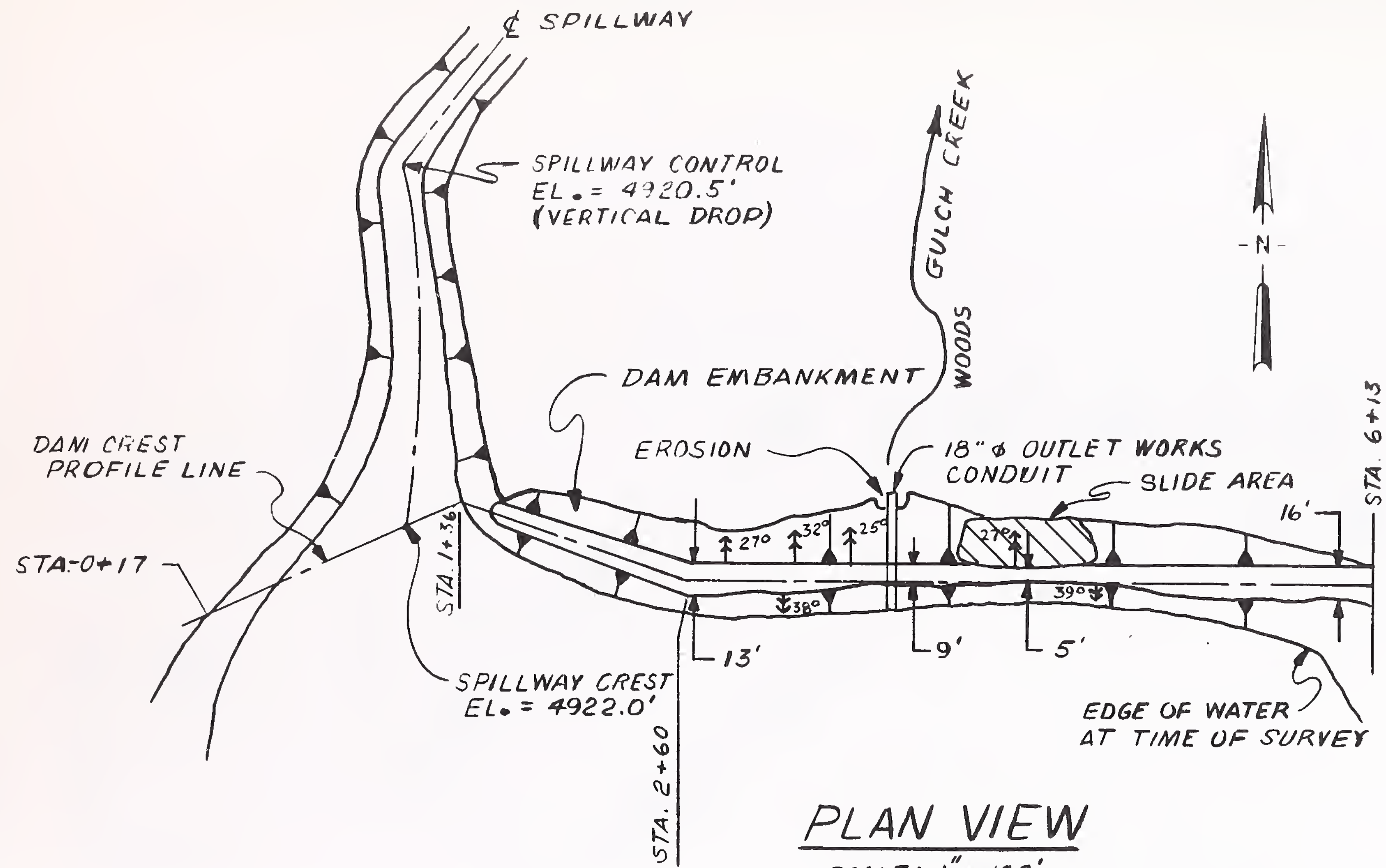
Photo No. 9 - Dam Embankment.
The dam embankment is shown looking westerly.

Photo No. 10 - Reservoir Basin.
Shown are the steep banks along the reservoir pool.

APPENDIX C

PROJECT DRAWINGS

Exhibit C1	Field Measured Plan, Cross Section & Embankment Slopes
Exhibit C2	Dam Crest Profile
Exhibit C3	Field Measured Profile & Cross-Section Of Spillway

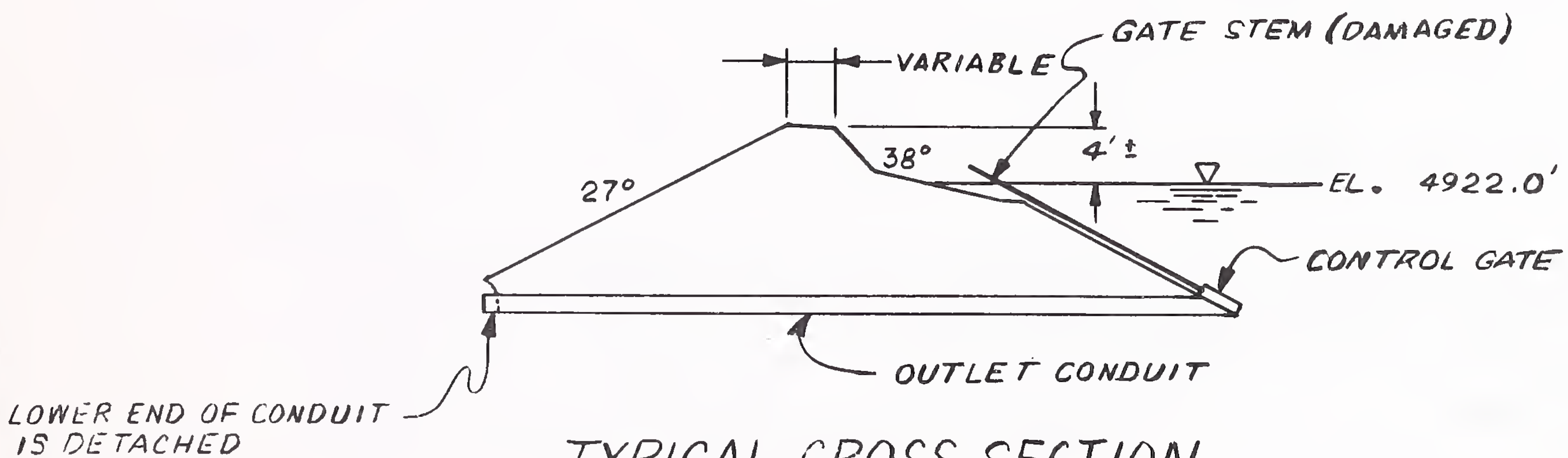


PLAN VIEW

SCALE: 1" = 100'

NOTES:

1. ELEVATION OF WATER SURFACE AND SPILLWAY CREST ASSUMED = 4922.0 FT (SEE NOTE, PG IX, IN TEXT)
2. DATE OF SURVEY: 6/25/80
3. SEE EXHIBIT C2 FOR DAM CREST PROFILE.



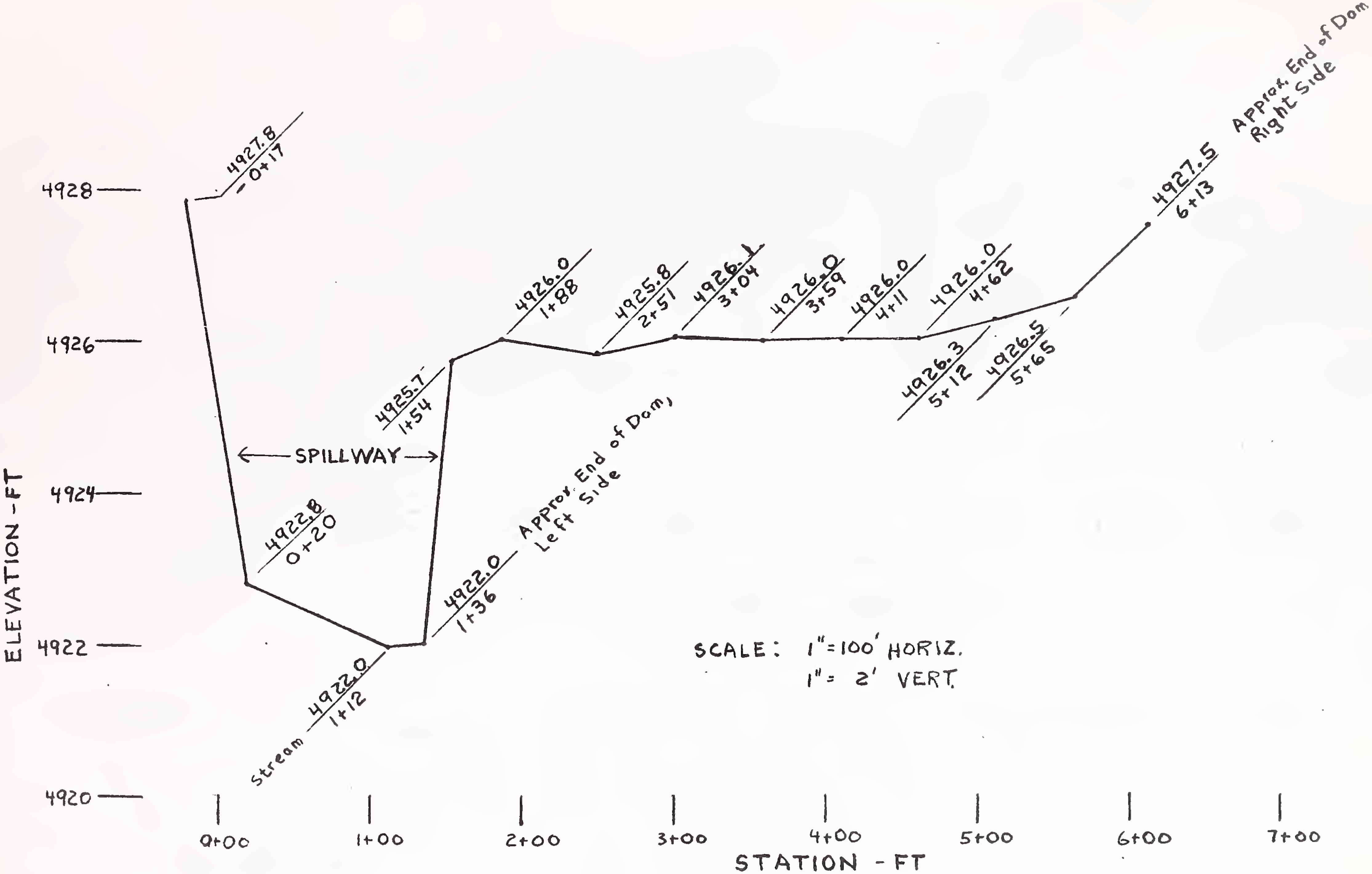
TYPICAL CROSS SECTION

NOT TO SCALE

EXHIBIT C1

FIELD MEASURED PLAN, CROSS SECTION, AND EMBANKMENT SLOPES

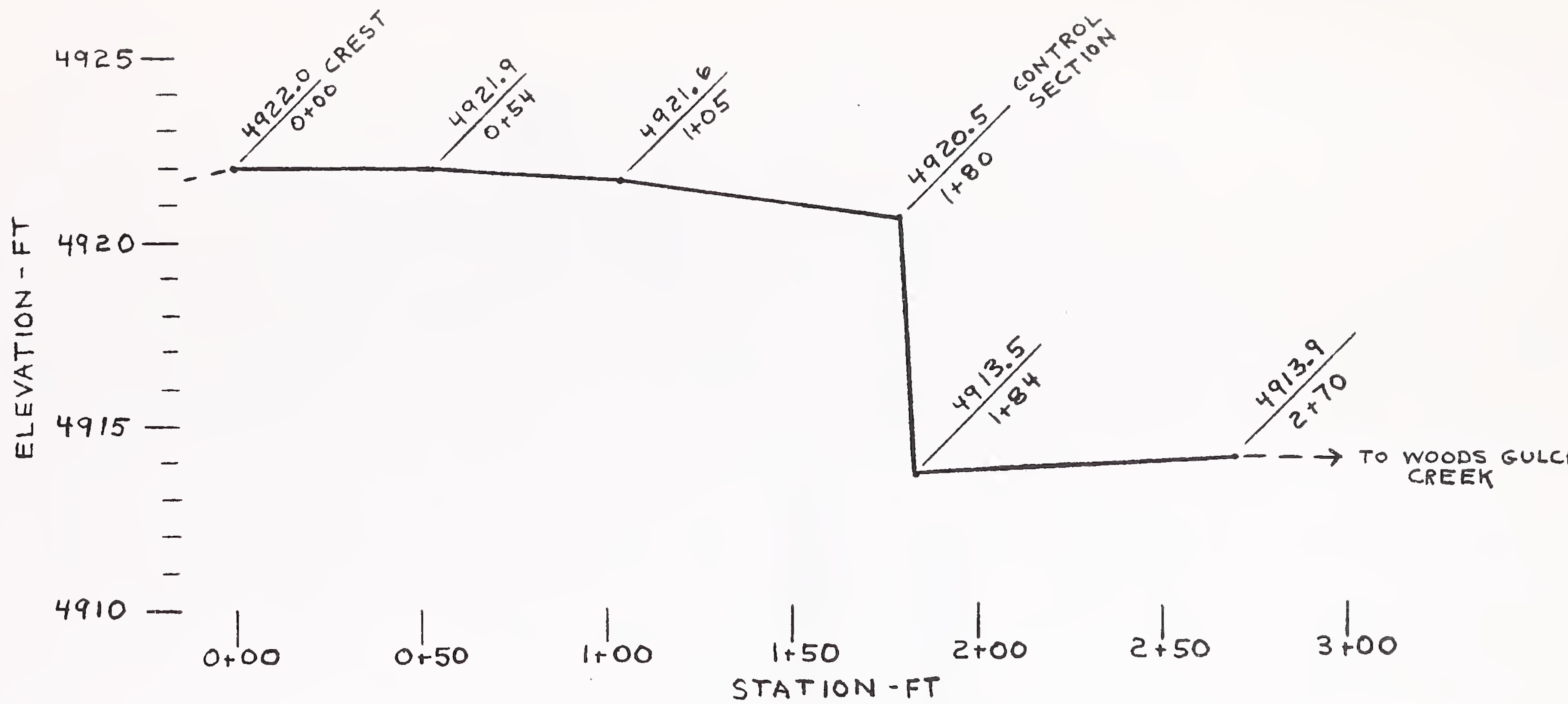
HANSON RESERVOIR DAM



NOTES:

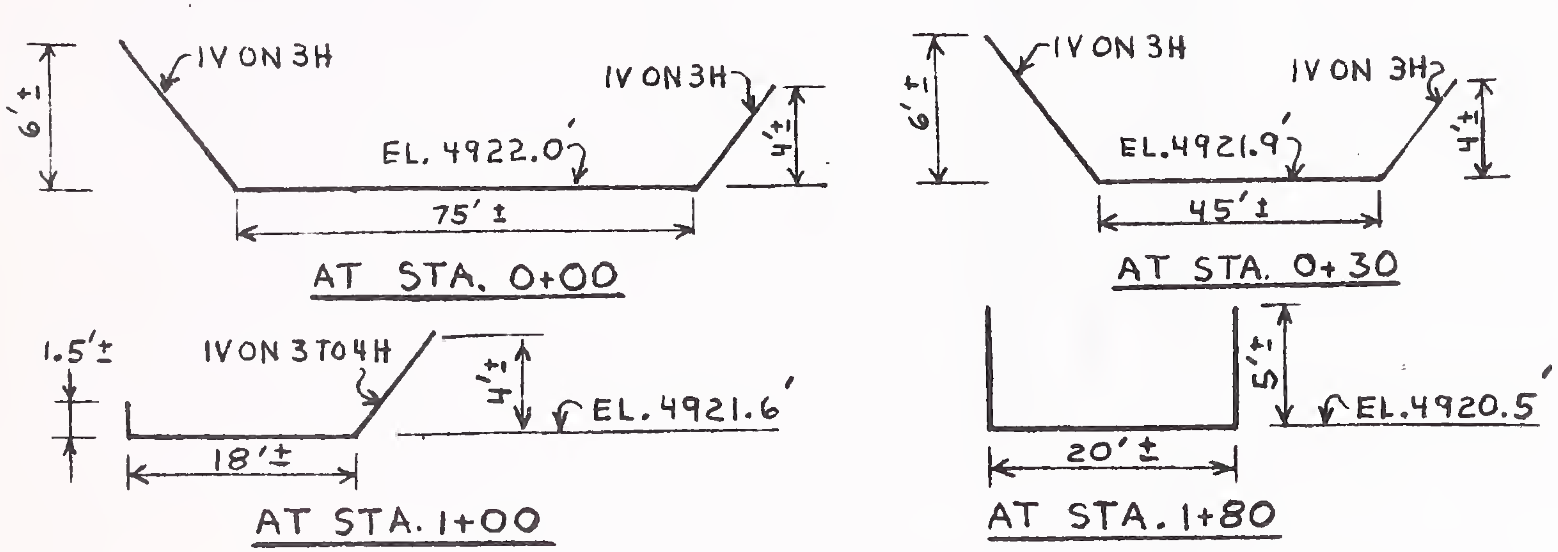
1. ELEVATIONS BASED ON WATER SURFACE EL. = SPILLWAY CREST EL. = 4922.0 FT (SEE NOTE, PG. IX, IN TEXT)
2. STATIONS & ELEVATIONS FROM HKM ASSOC. SURVEY - 6/25/80
3. SEE EXHIBIT C1 FOR PLAN VIEW OF DAM

EXHIBIT C2
DAM CREST PROFILE
HANSON RESERVOIR DAM



SPILLWAY PROFILE

Scale: 1" = 50' H, 1" = 5' V



TYPICAL SPILLWAY CROSS SECTIONS

Scale: 1" = 40' H, 1" = 10' V

1. EL. SPILLWAY CREST = 4922.0 FT (SEE NOTE, PG. IX, IN TEXT)
2. DATE OF SURVEY: 6/25/80
3. SPILLWAY CROSS SECTIONS ARE PERPENDICULAR TO ℄ SPILLWAY

EXHIBIT C3
FIELD MEASURED PROFILE & CROSS SECTION OF SPILLWAY
HANSON RESERVOIR DAM

APPENDIX D

ENGINEERING DATA

Exhibit D1	Elevation-Area Capacity Curves
Exhibit D2	Discharge Rating Table
Exhibit D3	Discharge Rating Curves

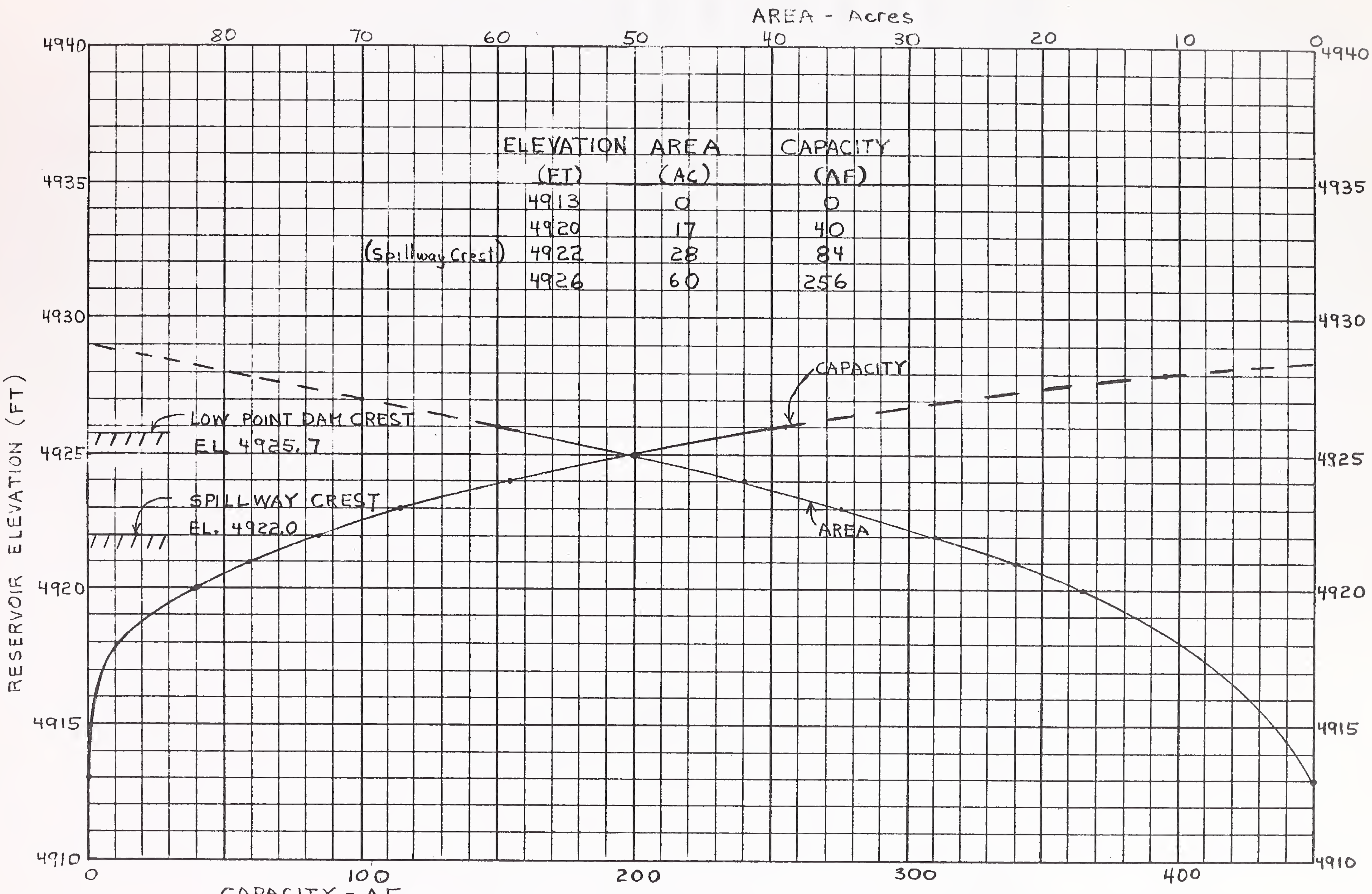


EXHIBIT D1
ELEVATION-AREA-CAPACITY CURVES
HANSON RESERVOIR DAM

EXHIBIT D2

DISCHARGE RATING TABLE

HANSON RESERVOIR DAM

RESERVOIR ELEVATION (FT)	OUTLET WORKS DISCHARGE (CFS)	SPILLWAY DISCHARGE (CFS)	TOTAL DISCHARGE (CFS)
4915 (Inlet Invert, Outlet Works, Est.)	0	-	0
4916	7	-	7
4918	10	-	10
4920	12	-	12
4922 (Spillway Crest)	14	0	14
4924	16	190	206
4925.7 (Low Point Dam Crest)	17	470	487
4926	17	520	537

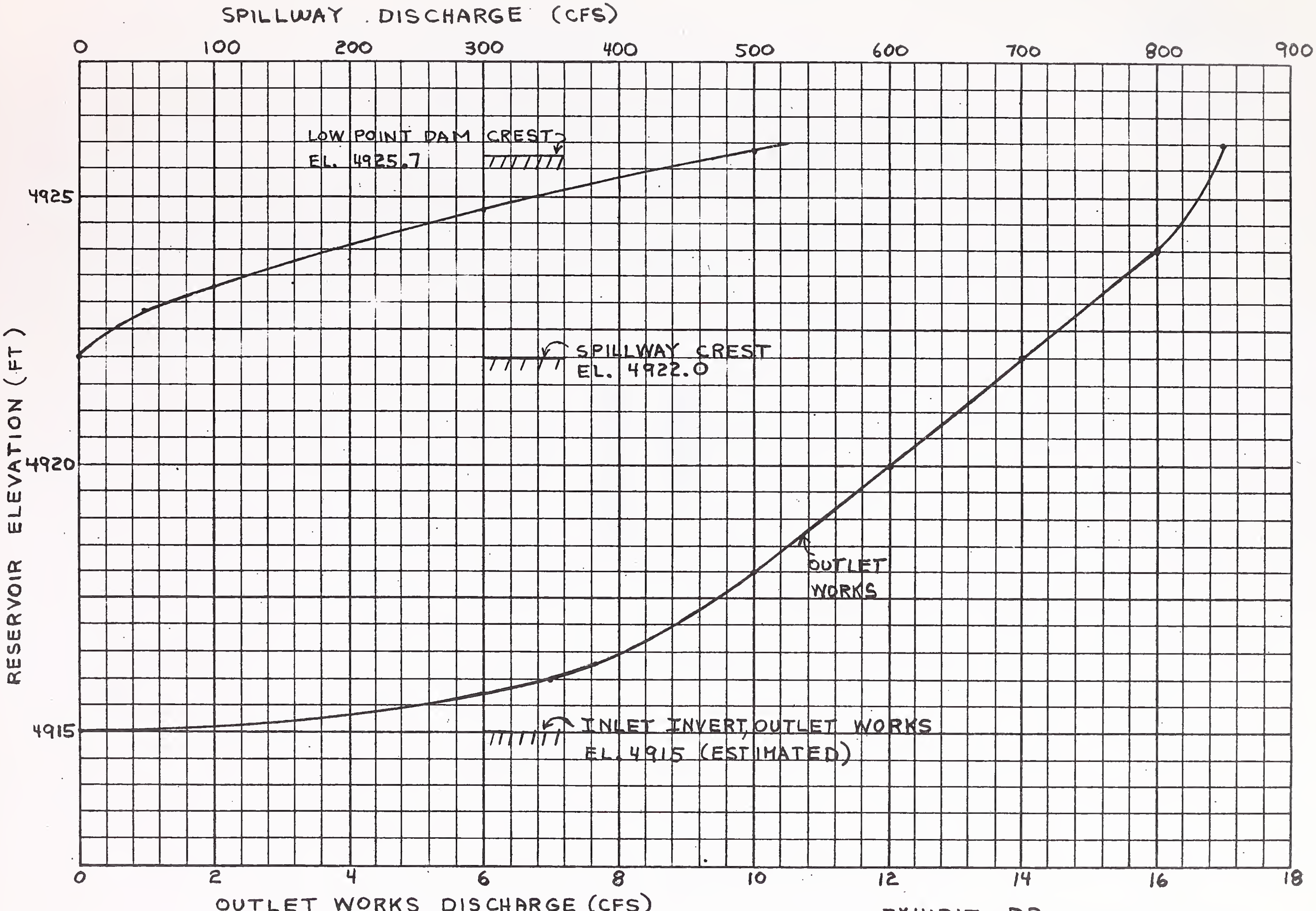


EXHIBIT D3
DISCHARGE RATING CURVES
HANSON RESERVOIR DAM

APPENDIX E

CORRESPONDENCE

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR 32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 HELENA, MONTANA 59601

January 22, 1981

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on the Hanson Reservoir Dam (MT-3207). We concur with the findings and recommendations in the report and feel that the report satisfies the criteria for the Phase I investigation. Our comments have been discussed with your staff and we understand that they will be incorporated into the final report.

We received a copy of a communication from Mr. Hanson which describes the work which he has performed on the dam since the inspection was made. We are sending you a copy of this communication as we believe that it should be included in the final report.

Thank you for the opportunity to review and comment on the final report for this project.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:LT:lj
enclosure

REPLY MESSAGE

TO Dept of Army
Corps of Engineers
P O Box C-3755
Scattle Wash 98124

FROM
RIVERSIDE RANCH CO.
Elmer D. Hanson
BOX ~~450~~ 529
WHITE SULPHUR SPRINGS, MONT. 59645

SUBJECT: Hanson Reservoir Dam DATE: Dec 6, 80

FOLD ↑ November 1980 a new 18" pipe was placed in This Dam with a 30" stand pipe & valve in the center of Dam Rock was placed at outlet Dam widened To 16 ft — course material on Face & Raised one ft.

PLEASE REPLY TO ⟶ SIGNED Elmer D Hanson

REPLY

DATE: SIGNED